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UNITED STATES
DEPARTMENT OF THE INTERIOR
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BUREAU OF MINES
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MINING AND MILLING METHODS AND COSTS AT THE ALICE UNIT OF THE AMERICAN SMELTING & REFINING CO., ALICE, COLO.

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MINING AND MILLING METHODS AND COSTS AT THE ALICE UNIT OF THE AMERICAN SMELTING & REFINING CO., ALICE, COLO.[1]

By Jos. R. Guiteras[2]

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[1] The Bureau of Mines will welcome reprinting of this paper provided the following footnote acknowledgment is used: "Reprinted from Bureau of Mines Information Circular 7058."

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INTRODUCTION

This paper is one of a series describing mining and milling methods and costs being published by the United States Bureau of Mines. It presents the results of a study of the Alice mine by the writer in December 1936.

ACKNOWLEDGMENTS

Acknowledgment is made to J. Fred Johnson, mining engineer of the American Smelting & Refining Co., for permission to visit the property; and to Arthur F. Johnson, general superintendent at the property, for his friendly cooperation in contributing the information contained in the paper.

SITUATION

The Alice mine is in the Upper Fall River mining district, Clear Creek County, in east-central Colorado. It is in the Pike National Forest at an altitude of 10,200 feet. The present mine workings are about half a mile west of the former post office at Alice, Colo. The most convenient market for supplies, and the railroad shipping point, is the mining town of Idaho Springs. The mine is reached from Idaho Springs via U. S. Highway 40 for 2-1/2 miles up Clear Creek to the mouth of Fall River, then via the Fall River road for 9 miles to the mine. Both roads are hard-surface dirt, good for haulage the year round; grades are moderate.

CLIMATE

The Alice mine is near enough to the town of Idaho Springs so that the climatological data for that town may be taken as a guide to conditions at the mine. Allowance should be made, however, for the fact that the mine is at an altitude of 10,200 feet, as compared to an altitude of only 7,556 feet for Idaho Springs.

According to the United States Weather Bureau,[3] the annual mean temperature at Idaho Springs over a period of 27 years was 43.1° F. The monthly mean temperatures during the same period ranged from 27.0° in January and December to 62.1° in July. The annual mean temperature in 1933 was 43.7°; the lowest that year was -29° in February, and the highest was 86° in July.

The mean annual precipitation at Idaho Springs over a 41-year period was 15.97 inches; it ranged from 0.34 inch in January to 2.86 inches in July. The total precipitation in 1933 was 15.80 inches. The greatest monthly precipitation in that year was 4.21 inches in April; the least was zero in October.

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[3] Colorado Year Book, 1933-34, (1934), pp. 84-86.

HISTORY

Mining activity at Alice began with placer operations on Silver Creek,[4] a branch of Fall River. In 1883, Alice was the site of the most extensive placer-mining operations in Clear Creek County. Burchard[5] describes the early hydraulic mines. According to that writer, the debris removed consisted of 3 to 6 feet of coarse gravel and soil, 2 feet of fine yellow dirt, and about 3 feet of shattered talcose bedrock. The yellow dirt was said to wash an inch string of gold to the pan. Locomotive headlights were used to permit working at night.

According to Bastin and Hill,[6] some $60,000 was said to have been recovered from the Alice property as a result of operations with hydraulic giants. Although the deposit was not a placer in the strict sense of the term, the acreage was originally located and patented as placer ground. Later, supplementary patents were obtained to cover all veins known to exist prior to the date of the placer patents.

Placer mining had disclosed a mineralized porphyry bedrock of commercial grade. A 27-stamp mill was erected, and for three seasons some of the free gold in the oxidized ore was profitably recovered by amalgamation. An adit was then driven to tap the ore body at depth, and a jig mill was built to treat the sulphides; that enterprise was unsuccessful.

About 1908, extensive amalgamation and table concentration tests were made on a 600-ton sample of ore from the mine. Assays of the sample showed the following metallic content:

Gold	0.168	ounce per ton
Silver ..	.886	ounce per ton
Copper ..	.38	percent

At the old gold price ($20.67 per ounce), the sample of ore was worth a little over $4 per ton.

In the years that followed, several large mining companies attempted to develop the property but were unsuccessful.

In January 1935, Porphyry Mines, Inc., took over the property on a lease and bond. From September 1935 to March 1936, this company treated about 12,000 tons in a 70-ton concentration mill. In March 1936, the American

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[4] Henderson, Chas. W., Mining in Colorado: Geol. Survey Prof. Paper 138, 1926, p. 32.

[5] Burchard, H. C., Report of the Director of the Mint Upon the Production of Precious Metals in the United States During the Calendar Year 1883: 1884, p. 280.

[6] Bastin, Edson S., and Hill, James M., Economic Geology of Gilpin County and Adjacent Parts of Clear Creek and Boulder Counties, Colo.: Geol. Survey Prof. Paper 94, 1917, pp. 325-326.

Smelting & Refining Co. assumed controlling interest. The mill was continued in service until June 1936. At that time, operations were suspended to build the present 200-ton mill. The new mill began operations on October 8, 1936. At the time of the writer's visit (December 1936), 200 tons per day were being mined and milled with a force of 24 men - an output of about 8 tons per man-shift.

GEOLOGY

The country rock at the Alice mine is a brecciated granite. The ore body is classified by Bastin and Hill[7] as a stockwork. According to them, it was formed by mineralization of an irregularly fractured body of porphyry. Mineralization was accomplished mainly by metasomatic replacement of the porphyry by the sulphide minerals; nests of sulphides as much as 3 inches across have formed at the intersection of fractures.

Some engineers believe that the ore body is in a quartz-monzonite dike that is nearly vertical and strikes approximately north. According to that view, the east and west limits of the ore body are the walls of the dike; the north and south limits of the ore are commercial. The management now believes that the ore is terminated on the west and the north by an aplite dike 15 to 25 feet thick that swings around those two sides of the ore body and dips toward the center at about 60°. The aplite dike is between the quartz monzonite and the surrounding granite.

The ore consists principally of pyrite with a subordinate amount of chalcopyrite in a gangue of quartz and siderite; it has a total value of $3 to $4 a ton. About 80 percent of the value usually is gold; silver and copper account for about 20 percent. Gold appears to be associated principally with the copper minerals, especially with the secondary sulphides and malachite.

WATER SUPPLY

Drinking water for the camp is obtained from a spring on the property. Water for milling purposes is brought from a creek flowing out of Loch Lomond through an old, mile-long, 10-inch pipe line that formerly had been used for hydraulicking operations; the grade ranges from 2 to 4 percent. The water is discharged into a screen box about 500 feet south of the mill; it is then delivered to the mill through a 4-inch pipe line. To prevent freezing in winter, a continuous overflow is permitted at the screen box, thus maintaining the flow in the 10-inch line; the 4-inch line is insulated with sawdust.

MINING

Development

A main 250-foot adit serves as a means of entry for men and supplies to the ore deposit. The ore is hoisted through an inclined skipway. The adit

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[7] Bastin, E. S., and Hill, James M., Economic Geology of Gilpin County and Adjacent Parts of Clear Creek and Boulder Counties, Colo: Geol. Survey Prof. Paper 94, 1917, p. 98.

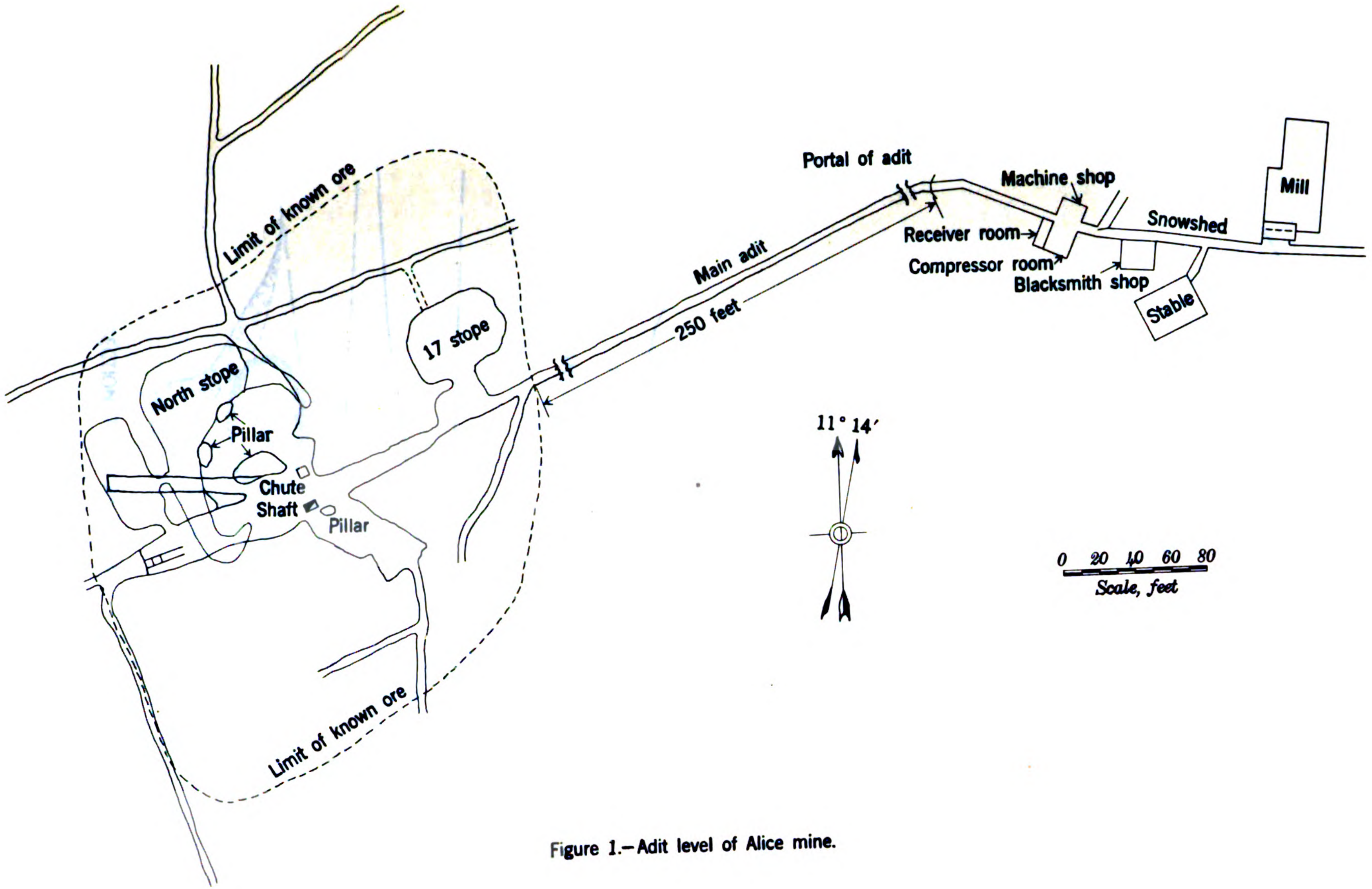
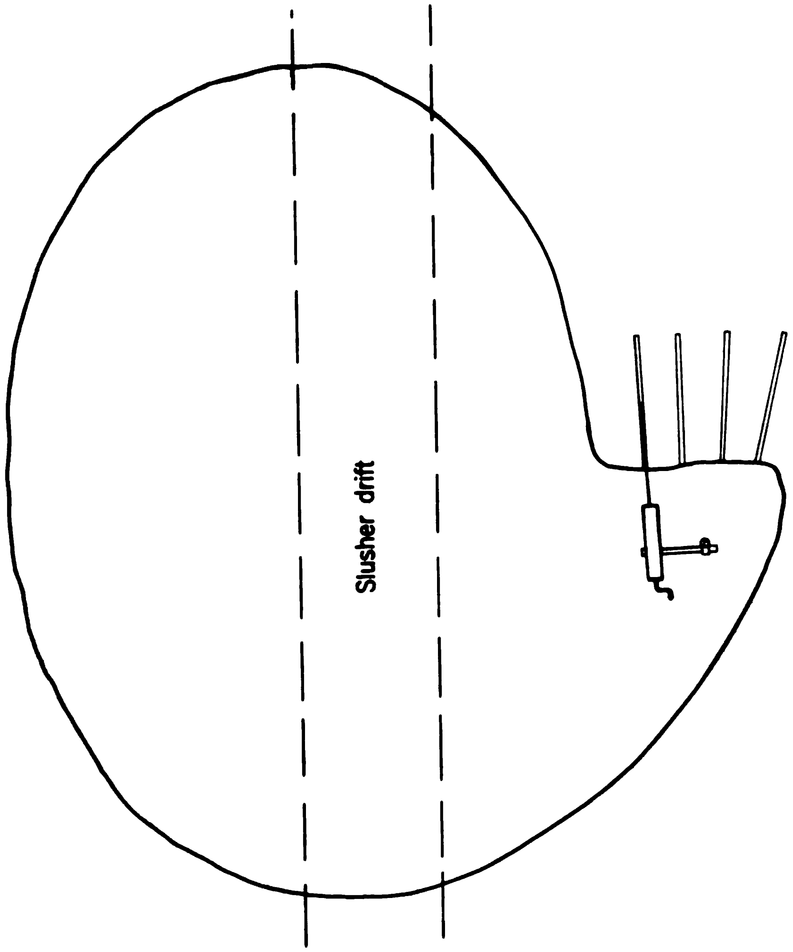
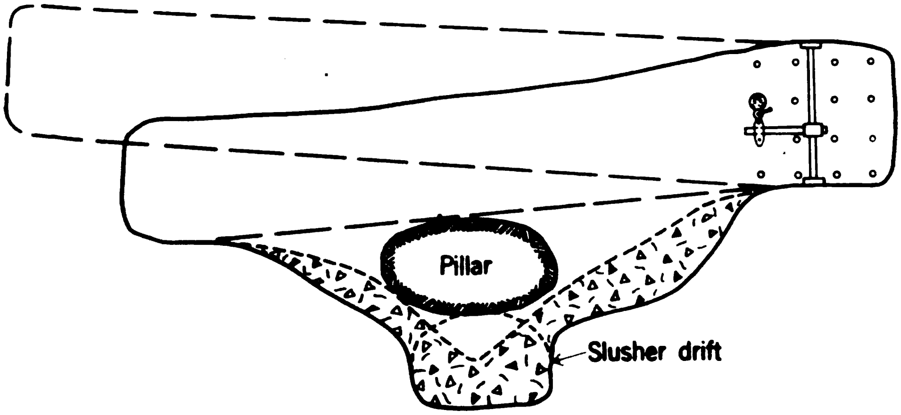


Figure 1.—Adit level of Alice mine.



PLAN OF STOPE



CROSS SECTION THROUGH STOPE

Figure 2.—Sketch of flat-spiral open stope (not to scale).

is preceded on the surface by about 200 feet of snowshed; both are electrically lighted. The adit is timbered with 10-inch round posts and caps; the cross section inside the timbers is 5 by 7 feet. The distance between sets is not uniform and they are closest together near the portal. Top and side lagging is of round poles 4 to 6 inches in diameter. The adit accommodates a track of 20-pound rails with a gage of 24 inches. In addition to the main adit, there are about 1,500 feet of drifts and crosscuts on the adit level (fig. 1).

From a point on the adit level near the center of the ore body, a 5- by 8-foot shaft has been sunk. The shaft is vertical for the first 40 feet; then it slopes at 70° toward the north to the 125-foot level.

Two levels have been opened below the adit - the 40-foot level, comprising about 100 feet of crosscuts west of the shaft, and the 125 foot level, comprising about 500 feet of drifts and crosscuts north and west of the shaft.

At the time of the visit (December 1936), no ore had been found below the adit level; since that time, however, the author has been advised that ore has been found on the 40-foot level. No exploratory or development work was being done at the time of the visit. Recent exploratory work with a churn drill south of the present ore body has given encouraging results. The management estimates 300,000 tons of ore, about one-third of it oxidized, above the adit level.

Stoping

The ore is mined by a combination of glory holes from the surface and open stopes from the adit level. Surface mining is done only in the summer; in December 1936, all of the output came from the underground stopes. The management anticipates an extraction of 100 percent of the ore body.

Open stopes have been started from places on the adit level where the ore was of relatively good grade. About 30 percent of the ore is left for pillars between stopes (fig. 1); an attempt is made to leave the poorest ore for that purpose. The pillars are mined later by glory holes from the surface. The ore is hard; it stands well in the pillars and in the walls of the stopes.

Preparatory to mining the North Stope, a drift about 15 feet wide and 10 feet high was driven on the adit level directly beneath the area to be stoped. Inclined raises 8 by 8 feet in section and 15 feet in length were driven at irregular intervals from both sides of the drift and funneled out to connect, leaving a 15-foot pillar above the drift. No chutes were built in the raises. The stope was then undercut by driving a flat spiral upward and outward to within 35 feet of the surface (fig. 2). Drilling was done with a drifting machine mounted on a vertical column. Holes were drilled forward to advance the spiral upward at about 10° from the horizontal along the stope wall. At the beginning of stoping operations, the back of the stope fell in rapidly enough to keep up with the back of the ascending spiral. As the spiral widened, however, the central part of the back of the stope failed to fall.[8] The main body of the North Stope had been mined by that method to a height of about 50 feet. Most of the broken ore was removed by a slusher operating in the drift below the stope. The slusher delivered the ore to a chute over an ore pocket, as described on page 7. Where the widening spiral caused the stope wall to become too flat for the broken ore to run down, a raise was driven from another slusher drift to tap it.

In December 1936, the North Stope was being enlarged by means of a series of flat curved cuts (segments of spirals), one above the other, following the west wall; drilling was being done in a number of working places about 20 feet above the adit level.

A drifting machine was used in each working place; the drill was mounted on a vertical column held in place between the broken ore and the overhanging inverted ledge of the stope wall. Slabbing rounds of six to eight flat holes were drilled about 10 feet deep; five or six sticks of 40-percent gelatin dynamite were used in each hole. The broken ore in excess of that required to form a working floor for the miners was removed by the slushers operating in the drift below. The ore tends to break large, thus necessitating considerable blockholing with jackhammers; this work was done on the adit level when the slushers had exposed a number of large boulders. In December 1936 about 20 such boulders were blasted per day; about half a stick of 40-percent dynamite was used in each hole. Blockholing was done by the hoistman's helper.

The drifting machines use 1-1/8-inch round steel; the jackhammers, 1-inch hexagon steel. Detachable bits range from 1-1/2 to 2-1/4 inches in gage; following gages differ by 1/8 inch. The bits are reground in the mine shop. Miners make up their own primers and take in steel and detachable bits as needed.

A glory hole about 100 by 200 feet across at the top had been opened above the center of the ore body. Work in the glory hole was done only in the summer. The barren surface overlying the ore was first removed by means of a two-drum slushing unit equipped with a 25-horsepower motor. The overburden was stripped to a depth of about 15 feet. The excavated material was scraped downhill into a 1-ton car that was parked below the overhanging edge of a short cut made for the purpose. The slusher hoist was mounted on a timber framework in the cut, high enough to allow the 1-ton car to pass underneath. The loaded car was trammed about 50 feet and dumped on the hillside. About 100 1-ton cars were loaded and dumped per day. Two men were employed in stripping; with one setting of the slusher hoist they could clear a strip of surface 100 feet long and 30 feet wide.

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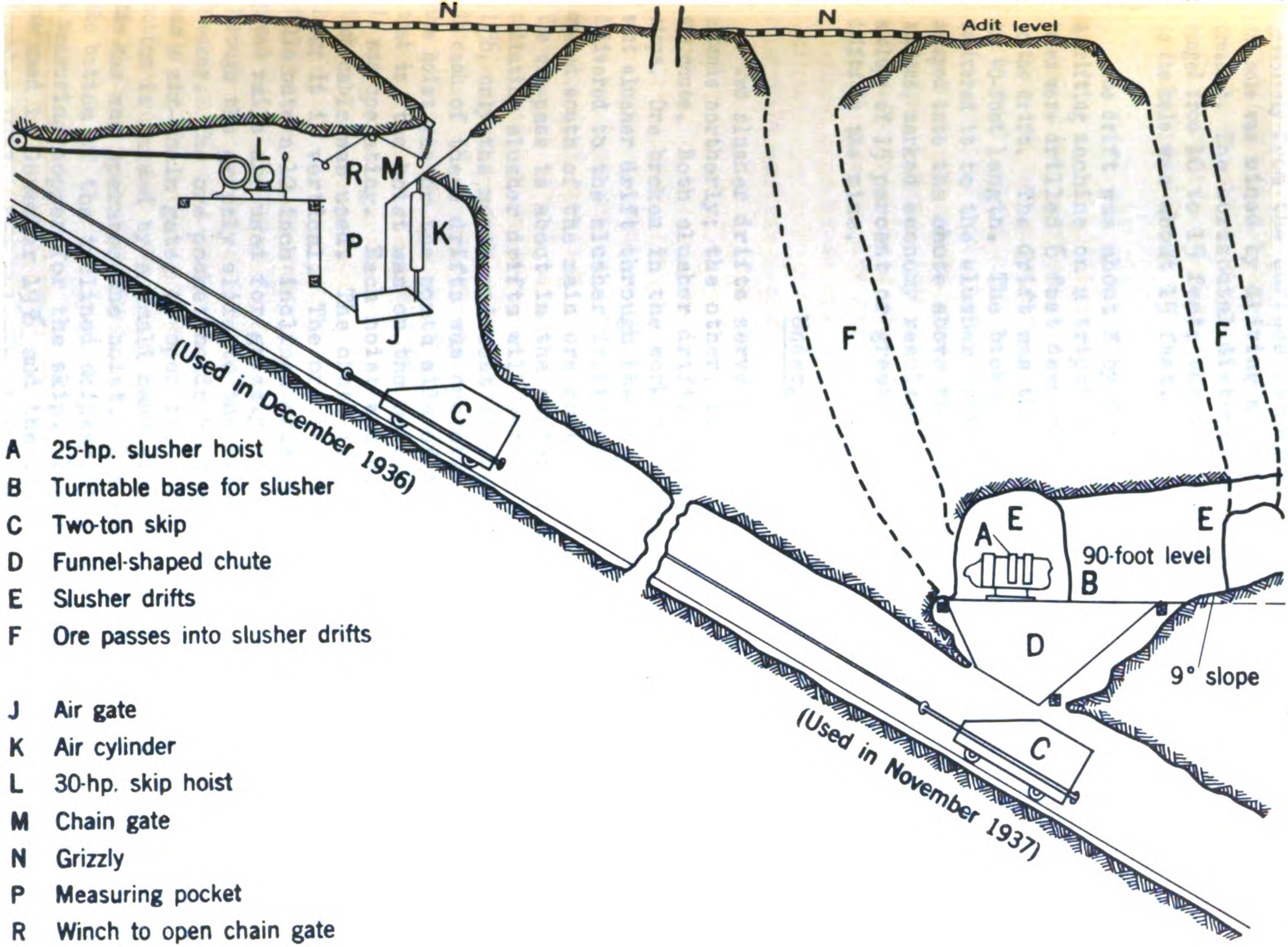
[8] In November 1937, some time after the spiral had attained its full height and stoping operations had ceased, the back of the North Stope caved to the surface.



A	25-hp. slusher hoist
B	Turntable base for slusher
C	Two-ton skip
D	Funnel-shaped chute
E	Slusher drifts
F	Ore passes into slusher drifts
J	Air gate
K	Air cylinder
L	30-hp. skip hoist
M	Chain gate
N	Grizzly
P	Measuring pocket
R	Winch to open chain gate

Figure 3.—Diagrammatic sketch of skip-loading devices at Alice mine.

The glory hole was started from a raise that reached the surface from the adit level. At first, work was by drilling and blasting benches progressively from the surface downward. During the summer of 1937, one end of the hole was mined by driving a drift just below the rim in the form of a crescent. The horizontal distance from the side of the hole to the drift ranged from 10 to 15 feet; the vertical distance from the back of the drift to the hole was about 15 feet.

The drift was about 8 by 8 feet in section and about 40 feet in length. A drifting machine on a tripod was set up at intervals along the drift, and holes were drilled 6 feet deep radiating in all directions in a plane normal to the drift. The drift was then blasted to the side of the glory hole over the 40-foot length. The broken ore was scraped into an ore-pass which delivered it to the slusher drift under the North Stope. From there it was scraped into the chute above the main ore pocket. In using scrapers on the surface, marked economy resulted from the practice of scraping downhill on a slope of 15 percent or greater, as compared to scraping in the level slusher drifts in the mine.

Underground Transportation

Two slusher drifts serve the North Stope; one, 7 by 8 feet in section, extends northerly; the other, 10 by 15 feet, extends westerly from the main ore chute. Both slusher drifts are on the adit level directly beneath the stope. Ore broken in the work of enlarging the North Stope feeds into the west slusher drift through the stope raises. Ore from the glory holes is delivered to the slusher drifts by ore-passes. A slusher drift has been opened south of the main ore chute, and another is to be driven easterly. The ore-pass is about in the center of the ore body, so that the system of radiating slusher drifts will serve almost the entire tonnage. In December 1936, only the north and west slusher drifts were being used. A 4-foot slusher in each of these drifts was operated by one of two 3-drum hoists at the chute. One hoist was on the south side of the chute, the other on the east side; that is, the hoist was on the opposite side of the chute from the slusher it was operating. Each hoist was equipped with a 30-horsepower motor; 5/8-inch cable was used. The chute is 6 feet square at the top and about 8 feet long; it is vertical. The ore is scraped to the chute by the slushers and falls onto a 12-inch inclined grizzly over the main ore pocket. Seventy-pound rails are used for grizzly bars. Boulders that are too large to pass through the grizzly slide to the lower end, where they are split by a paving-breaker. The ore pocket holds 50 tons; that is, it "draws" that much. It has a six-chain gate; to open it, a bar connected to all the chains near the bottom is raised by a small hand windlass, this operation being performed by the man who operates the hoist. The gate of the ore pocket is just above the bottom of the inclined skipway; the ore from the gate drops directly into a measuring hopper for the skip. Figure 3 shows the skip-loading device that was used in December 1936 and the improved arrangements inaugurated in November 1937. The skipway slopes upward at a 30° angle from the ore pocket directly to the crushing plant at the surface. It is about 225 feet in length and 6 by 6 feet in cross section; it is timbered near the surface.

The track gage is 48 inches; 52-pound rails from an abandoned street-car line are used. A 2-ton self-dumping skip is operated by a hoist on a platform over the measuring pocket. The hoist is equipped with an indicator and is driven by a 30-horsepower motor. The hoistman, from his position at the measuring pocket, performs all loading and hoisting operations. A round trip of the skip, including loading and dumping, takes about 2-1/2 minutes. The skip dumps its load into a 70-ton coarse-ore bin at the crushing plant.

Drainage and ventilation

All water in the mine workings flows in from the surface and is therefore seasonal in quantity. Most of the water is intercepted on the adit level and runs out a drain cut along one side of the main adit. Water that seeps through the ore body below the adit level collects in the lower levels and in the shaft. A small air-driven centrifugal pump is at the shaft on the 40-foot level; it can keep the water in the shaft at that level by working only half an hour a day, except in the spring, when it runs 18 hours a day. The small amount of water that seeps into the inclined skipway runs through a drill hole into the 40-foot level and thence into the shaft.

Connections between some of the shrinkage stopes and surface glory holes permit circulation of abundant fresh air in the mine.

Mine Shops

The compressor room and the blacksmith and machine shops are alongside the snowshed connecting with the main adit. In the compressor room are two V-type 300-cubic-foot compressors; only one is used at a time. Each compressor is driven by a 50-horsepower motor at 870 r.p.m. Air is delivered at a pressure of 110 pounds per square inch to a 4- by 9-foot receiver. It enters the mine through a 4-inch main air line, which is reduced to a 3-inch and then to a 2-inch line before it reaches the ore body. In the blacksmith shop is a small forge with the usual accessories. The machine shop contains a grinding wheel for sharpening detachable bits.

Mine Labor

All the workmen at the mine and mill live at the mine or in the nearby town of Alice. In December 1936, six men were living with their families at the mine and five at Alice. Two single men were "batching" at the mine. The other men at the mine were living in a bunkhouse and paid $1.35 a day for meals and lodging. Each man punches a time card in a time clock on his way to work and again when he quits work for the day. Each time card covers a 2-week period; space is provided for the workman to designate his working place and nature of the work done each day.

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In December 1936, 14 men were working in the mine; the tabulation below shows their duties and wages.

Daily mine labor, December 1936

	Rate	Total
3 hoist and slusher men..........	$5.50	$16.50
3 hoist and slusher men.. helpers	4.50	13.50
1 blacksmith.....................	5.00	5.00
1 blacksmith............. helper	4.00	4.00
1 mine foreman...................	$200 per month	6.67
4 miners.........................	5.00	20.00
1 engineer.......................	4.50	4.50
14		$70.17

In addition to the above, one-half of the salary of the superintendent is charged to the mine.

Cost of Mine Supplies

The following list shows the prices paid for mine supplies as of December 1936.

Cost of mine supplies (delivered), December 1936

Dynamite, 40-percent......	$13 per 100 pounds
Fuse......................	$0.007 per foot
Carbide...................	$7 per 100 pounds
Caps:	
No. 6................	$0.013 each
No. 8................	$0.02 each
Timber....................	$30 per M feet b.m.

MILLING

Mill

The Alice mill, exclusive of the crushing plant, is a compact unit of the side-hill type. In December 1936, it was running at full capacity of 200 tons per day. The building is heated in winter by a steam radiator equipped with a fan, situated on the lowest floor of the building. The steam is supplied at a pressure of 5 to 15 pounds per square inch by a small boiler, which consumes about 200 pounds of coal per day. The crushing plant, including a coarse-ore bin, is situated about 300 feet from the mill building, up the slope toward the mine; a snowshed housing a belt conveyor connects it to the mill building. Ore from the mine is dumped directly into the coarse-ore bin. Many samples are cut in the mine and many grab samples are taken each day.

Formerly, the gold in the ore was recovered satisfactorily by amalgamation. The copper appeared to be worth saving, however, and as it would interfere with cyanide treatment, the present flow sheet was adopted (see fig. 4). Probably more of the silver is recovered by this treatment than would be recovered by cyanidation. Most of the gold still is saved by amalgamation. The copper recovered pays the milling cost.

Milling Method

Ore is delivered to the mill crushing plant by the 2-ton self-dumping skip previously described. For tonnage calculations, a skip load is 1.7 tons. The coarse-ore bin holds 70 tons.

A vibrator feeder delivers the ore from the bottom of the coarse-ore bin to a 30-inch belt conveyor 15 feet long, which is driven by a 2-horsepower motor. Tramp iron is picked out of the ore by the crusher man. The management expects to employ ore-sorters soon. It is estimated that 5 percent of the ore could be picked off the belt and discarded as waste. The conveyor dumps the ore onto a grizzly 3 feet long with 2-1/2-inch spaces between the bars; the grizzly is inclined at 45°. Only about 5 percent of the ore passes through the grizzly. The oversize is delivered to a 15- by 38-inch jaw crusher, which is driven at 305 r.p.m. by a 60-horsepower motor; V-belt drive is used. The crusher is operated one-half to two-thirds of the time. The ore is easily crushed. The crusher jaw plates are of molychrome steel and are replaced monthly. The crusher is set at 2-1/2 inches. The crushed ore and the grizzly undersize drop onto a 16-inch belt conveyor 335 feet long. The conveyor, driven by a 5-horsepower motor, travels at 200 feet per minute; the grade is slightly downward for the first 215 feet, then horizontal. The crushed ore drops into a fine-ore bin holding 150 tons, situated at the top of the mill building. From the bottom of this bin, a vibrator feeder delivers the ore to a 6- by 6-foot cylindrical ball mill.

The daily mill-head sample is a composite of hourly samples taken by hand at the feeder to the ball mill; the full stream of ore is taken. Assays of head samples show an average of 0.12 ounce of gold per ton, 0.70 ounce of silver per ton, 0.4 percent copper, and about 7 percent moisture.

A 125-horsepower motor drives the ball mill at 25 r.p.m. by a V-belt drive. The ball load is 12,000 to 14,000 pounds of 5-inch forged-steel balls, and ball consumption is 1 pound per ton of ore. Manganese-steel liners are used, a set of which lasts about 6 months. In the process of relining the ball mill the old liners are carefully washed as removed, and the material that has collected in the cracks between them is saved; the 6-month yield is about 200 ounces of gold as amalgam. Lime and mercury are fed into the feedbox of the ball mill. The purpose of the lime is to depress iron in the flotation machines that follow. The lime is contained in a small wooden bin, from the bottom of which it is delivered continuously by a mechanical feeder. About 1 pound of lime is added per ton of ore. About 0.1 ounce of mercury per ton of ore is added by hand every half hour. The ball-mill product passes into a trommel 2 feet in diameter and 3 feet in length; the screen has punched

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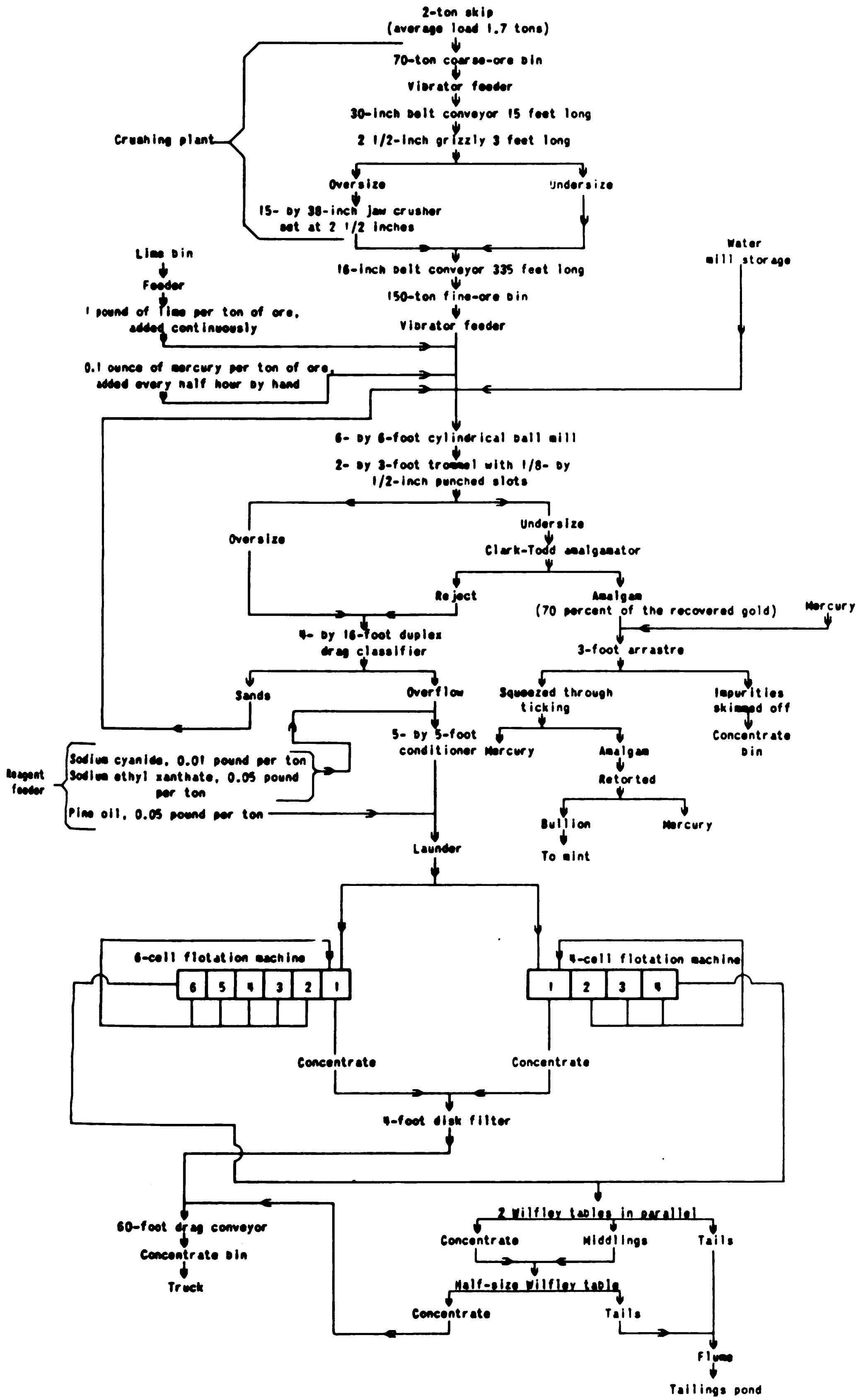

Figure 4.- Flow sheet, Alice mill.

slots 1/8 by 1/2 inch. The trommel oversize is conveyed in a short wooden launder to a 4- by 16-foot duplex drag classifier driven by a 2-horsepower motor. The trommel undersize runs into a Clark-Todd amalgamator. The tailing from the amalgamator passes to the classifier. Seventy percent of the gold extracted from the ore is recovered in the amalgamator.

The amalgamator is cleaned up every 2 weeks; it takes about 2 hours to change the pans. The amalgam is treated in a 3-foot arrastre with 50 to 70 pounds of mercury. The impurities are skimmed off and thrown into the concentrate bin. The mercury is squeezed through pillow ticking; the lumps of amalgam are retorted. The mill produces about 350 to 400 ounces of bullion per month containing gold 810 to 825 fine and silver about 175 fine, which is delivered to the Denver mint. The mercury lost amounts to about 1/20 ounce per ton of ore. Most of this is floured mercury, which passes into the flotation concentrates.

The sands from the duplex drag classifier are returned to the ball mill, thus making a closed circuit. The classifier overflow has a pulp density of 1.36, and a screen analysis shows the following distribution of sizes:

	Percent
Plus 48 mesh....................	17
Minus 48 mesh, plus 100 mesh.....	28
Minus 100 mesh, plus 120 mesh....	18
Minus 120 mesh..................	37
	100

The classifier overflow passes into a 5- by 5-foot conditioner, which is driven at 300 r.p.m. by a 2-horsepower motor. Sodium cyanide (0.01 pound per ton of ore) and sodium ethyl xanthate (0.05 pound per ton) are added to the pulp in the conditioner by a reagent feeder of the revolving-bucket type. Pine oil (0.05 pound per ton of ore) is fed into the launder that conveys the pulp from the conditioner to the flotation machines. The conditioned pulp is divided between a six-cell and a four-cell flotation machine; the feed enters the first cell of each machine. A concentrate is made in the first cell, which also receives the froth from the remaining cells. The six-cell machine is driven by three 3-horsepower motors; the four-cell machine by two 2-horsepower motors. The flotation tails pass to two Wilfley tables operated in parallel; each is driven by a 1-1/2-horsepower motor. The concentrates are washed down a short launder to a 4-foot disk filter, which is driven by a 2-horsepower motor. The vacuum pump for the filter is driven by a 3-horsepower motor. A rotary blower driven by a small motor supplies air at a pressure of 10 pounds per square inch for releasing the filter cake. The filtered concentrates contain 12 percent moisture. The water recovered by the filter is returned to the flotation circuit by a 1/4-horsepower centrifugal pump. The concentrates and middlings from the Wilfley tables are treated together on a half-size table.

The tails from the small table, which contain about 0.1 ounce of gold per ton, go to waste. The concentrate made on the small table accumulates in a tub, from which it is shoveled periodically into the feedbox of a drag conveyor. The filtered flotation concentrates drop into the same feedbox. About 4 tons of flotation concentrate are made to 1 ton of table concentrate. The drag conveyor is 60 feet long and it is driven at a speed of 30 feet per minute by a 1-horsepower motor. The concentrates are dragged up a vertical height of 20 feet and dumped into a cribbed bin. The bin holds 30 tons of concentrates; it has a 20-inch gate in the bottom for loading the 4-ton company truck. The average output of concentrates is about 6 tons per day.

Grab samples of the concentrates are taken hourly by hand. The table concentrates assay 0.8 ounce gold per ton, 8 ounces silver per ton, and 7 percent copper. The flotation concentrates assay 1 ounce gold per ton, 15 ounces silver per ton, and 10 percent copper. The tailing flume is a 6-inch box, 1,700 feet long, with a grade of about 4 percent. The flume is lined with 4-inch (inside diameter) drain tile to prevent settling of the sands; the tile is packed with coarse tailings to prevent freezing. The tailings are conveyed to a depression below the mill, where they are impounded behind a dam. An automatic sampler shows that the tailings contain an average of 0.015 ounce of gold and 0.20 ounce of silver per ton.

The ratio of concentration in November 1936 was 22 to 1. The recoveries are stated to be 82 percent of the gold, 70 percent of the silver, and 70 percent of the copper.

The mill uses about 3-1/2 tons of water per ton of ore.

Marketing Concentrates

Concentrates are hauled continuously to Idaho Springs, where they are loaded into 25-ton narrow-gage railroad cars. When two cars have been loaded, they are shipped via the Colorado & Southern Railroad to Denver. At Denver, the concentrates are transferred to a 50-ton standard-gage car and shipped via the Denver & Rio Grande Western Railroad to the American Smelting & Refining Co. copper smelter at Garfield, Utah. The freight rate on concentrates from Idaho Springs to Garfield averages about $6 per ton; no charge is made for transferring the load from narrow-gage to standard-gage cars at Denver.

The figures below are taken from a recent smelter settlement sheet and show the method of payment for concentrates:

American Smelting & Refining Co., Garfield Plant

Concentrates received Nov. 23, 1936.

Metal quotations: Gold, $34.9125; silver, $0.77; copper, 10.275 cents less 2.025 cents.

Settlement assay: Gold, 0.73 ounce per ton; silver, 16.8875 ounces per ton; copper, 8.515 percent.

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Values per ton:			
Gold at	$32.31825	per ounce	$23.59
Silver, 95 percent at	.77	per ounce	12.35
Copper, less 0.5 percent at	1.65	per unit	13.22
Total values			49.160
Less total deductions			3.125
Net value per ton			46.035

Deductions per ton:	
Base charge	$3.00
Labor increase	0.125
Total deductions	3.125

	Pounds
Wet weight of concentrates	111,660
Less moisture, 9.8 percent	10,942
Dry weight	100,718

Value of shipment 50.359 tons at $46.035		$2,318.28
Less: Freight at $6.50 per ton	362.90	
Assaying	4.00	366.90
Net proceeds		1,951.38

Mill Labor

In December 1936, nine men were working in the mill. Their duties and wages are shown in the following tabulation:

Daily mill labor, December 1936[1]

	Rate	Total
3 mill operators	$5.00	$15.00
3 mill helpers	4.00	12.00
1 maintenance man	5.00	5.00
1 foreman	200.00 per month	6.67
1 truck driver	5.00	5.00
9		43.67

[1] Excludes one-half of the salary of the superintendent, which is charged to the mill.

Cost of Mill Supplies

The following list shows the prices paid for mill supplies in December 1936:

Cost of mill supplies (delivered), December 1936

Sodium-ethyl xanthate	$16.00 per cwt.
Lime	18.00 per ton
Pine oil	9 cents per pound
Lubricating oil	60 cents per gallon
Coal for heating	8.50 per ton
Manganese-steel crusher jaw plates	400.00 per set
Molychrome-steel crusher jaw plates	150.00 do.
Manganese-steel ball-mill liners	1,800.00 do.

POWER

Electric power for the mine and mill is supplied by the Public Service Co. of Colorado; most of it is generated in a hydroelectric plant on Fall River between the mine and Clear Creek. The power is brought in to the property at 23,000 volts; it is stepped down to 440 volts for the motors and to 110 volts for lighting.

Power consumed during November 1936 amounted to 94,000 kw.-hr.; the average of three 5-minute peaks was 257 horsepower. The cost of power for that month was $1,249.00, or at an average rate of about 1.33 cents per kw.-hr. Two-thirds of the cost of power is charged to the mine and one-third to the mill.

SUMMARY OF COSTS

Average mining and milling costs, as estimated by the management, are as follows:

Cost of mining and milling per ton of ore, December 1936[1]

	Labor	Supplies	Power	Total
Mining......	$0.52	$0.25	$0.13	$0.90
Milling.....	.38	.15	.07	.60
Total.......	0.90	0.40	0.20	1.50

[1] Overhead, taxes, insurance, and other direct costs are omitted in this table.

The Alice mine closed down October 31, 1938. A summary of the mining and milling costs for September 1938, representative of the final stages of operation, is given below. During that month, 7,814 tons of ore were mined and milled.

Cost of mining and milling per ton of ore, September 1938

	Labor	Supervision	Supplies	Power	Transpor-tation	Taxes and insurance	Total
Mining 1/....	$0.465	$0.037	$0.232	$0.114	$0.006	$0.072	$0.926
Milling.....	.234	.029	.264	.114	2/ .103	.040	.784
Total.....	0.699	0.066	0.496	0.228	0.109	0.112	1.710

1/ Includes exploratory drifting: 160 feet at $7 per foot = $1,120.00.
2/ Includes hauling of concentrates to Idaho Springs at 78 cents per ton.